

CHAPTER 12

LIFE SCIENCES, ALCHEMY AND MEDICINE

I. INTRODUCTION

The Islamic conquest of Persia enabled the Persians to become members of a truly international society and to participate in a world-wide civilization in whose creation they themselves played a basic rôle. A homogeneous civilization which spread from the heart of Asia to Europe, possessing a common religion and a common religious and also scientific language, facilitated the exchange of ideas and prepared the ground for one of the golden ages in the history of science, in which the Persians had a major share. Islamic science came into being in the 2nd/8th century as a result of the vast effort of translation which made the scientific and philosophical traditions of antiquity available in Arabic. This early phase of activity reached its peak in the 4th/10th and 5th/11th centuries just before the Saljuq domination. During this period, which is among the most outstanding in the history of science, Persia was the main theatre of scientific activity, and although there were certainly many Arab and other non-Persian scholars and scientists, most of the figures who contributed to the remarkable philosophical and scientific activity of the age were Persians.

In a sense the scientific activity of this period continued what had been begun during the late Sāsānian period, but on a much greater scale and with a more universal scope. During the late Sāsānian period, there was some notable activity in astronomy, as seen in the *Zīj-i Šahriyār*, and also in medicine and pharmacology in which the activity of Burzūya, his journey to India and his causing the translation of Sanskrit texts into Pahlavī are reflected in later pages of history. Moreover, Jundīshāpūr had become a major medical centre after the destruction of Edessa by the Byzantines in A.D. 489, and it was the most important medical centre of the ancient world at the time of the Islamic conquests. In botany and pharmacology, there was already a great deal of exchange between Sāsānian Persia and China, as well as

INTRODUCTION

some knowledge of Greek sources. Even in the occult sciences, alchemy and metallurgy, it seems that some contacts existed in Iran with Chinese and Alexandrian sources. There are many treatises of the occult sciences of Hermetic origin attributed to Zoroaster and originally translated from Greek into Pahlavī, along with other translations in more openly disseminated sciences such as logic.

This interest in science during the late Sāsānian period is reported in Arabic sources to have been associated more with the Syriac language than with Pahlavī. Although there were certain translations of scientific texts into Pahlavī, the Pahlavī language remained mostly the philosophico-religious language of Sāsānian Persia, as seen in such works as the *Bundahishn* and *Dēnkart*, while most of the teaching and discourse on the sciences in Jundīshāpūr were carried out in Syriac, a sister language of Arabic. This fact itself facilitated the transition to the Islamic period, for soon Arabic, another Semitic language, was to replace Syriac as the scientific language of the region. The Sāsānian experience certainly made it easier for the Persians to make the transition and to learn to master Arabic, a language which enabled the Persians to reach a world-wide audience for the first time. Besides being their religious language, Arabic became for the Persians a scientific language of great precision and wealth which they themselves helped to make the most important scientific language of the world for seven or eight centuries.

It is well known that the Arabic prose connected with the religious sciences such as Qur'anic commentary and *ḥadīth* differs in style from the prose of scientific and philosophical works. Persian scholars like Ibn al-Muqaffa' had a major rôle in developing this scientific prose, and the whole class of clerks and civil administrators which was so responsible for the cultivation of the sciences in the early Islamic centuries consisted mostly of Persians, who entered the civil service in large numbers. Although perhaps it is an exaggeration to say that the Persians created philosophical and scientific Arabic prose, it is certainly justifiable to state that they had a major rôle in its development. They were instrumental in creating a vehicle for the expression of exact thought which enabled them to reach an international audience which had never been available to them before. Besides the spiritual transformations brought about by the Qur'anic revelation, the availability of the Arabic language, and a world-wide civilization which facilitated intellectual communication and the exchange of ideas must be

considered as the major factors which enabled the Persians to achieve so much in the domain of abstract thought. If the Achaemenian period is the golden age of Persia politically and the Sāsānian period in administration, city planning and architecture, the first centuries of the Islamic period are without doubt the golden age of Iranian history in the domain of the sciences, particularly medicine and mathematics. To this period belong those Persian scientists who stand among the foremost stars in the firmament of the history of science to this day.

II. THE TRANSLATORS

The transition from the Sāsānian to the Islamic era in the sciences is marked by the period of translation from Graeco-Syriac, Pahlavī and Sanskrit sources into Arabic. In this very important process the majority of translators were Christian and Harranian, but the Persians also had a major rôle, especially in making available works of Pahlavī in the Arabic language, which the Persians, like other Muslims, adopted rapidly as the scientific and philosophical language of discourse. To mention the names of some of the translators of a Persian background, such as Jirjis b. Bukhtyishū‘, Yuḥannā b. Māsūya (usually pronounced Māsawaih), Ibn al-Muqaffa‘, ‘Umar b. Farkhān al-Ṭabarī, Muḥammad al-Fazārī, Naubakht al-Ahwāzī and ‘Alī b. Ziyād al-Tamīmī, is sufficient to demonstrate the important rôle the Persians had in the process of translation and transmission itself. Moreover, certain Persian families acted as patrons and supporters of the new scientific movement, of which the Barmakids and the Naubakht family are well known examples.

As a result of this concerted effort, encouraged by the caliphate itself, and made necessary by the inner dynamics of the newly born Islamic society, the Persians found themselves in possession of a wealth of sources in the different sciences which could act as raw material for the birth of the Islamic sciences. The availability of these sources, the new cultural climate and the presence of the new scientific language, which the translations themselves had helped forge into a most exact instrument for the expression of abstract thought, all helped to make possible the ever increasing activity in the sciences which reached its crescendo in the 4th/10th and 5th/11th centuries with such figures as Ibn Sīnā and Bīrūnī. As far as the medical and biological sciences are concerned the presence of Jundīshāpūr as a living centre where

THE TRANSLATORS

medicine of the Hippocratic and Galenic traditions had been preserved, along with those of the Persian and Indian, made the transition from the world of ancient science to Islamic science more continuous and coherent. It was upon this existing background that suddenly such giants as Ṭabarī and Rāzī burst upon the scene in the 3rd/9th and 4th/10th centuries.

III. THE LIFE SCIENCES

It has been customary for historians of science in the West to apply categories of modern Western science to Islamic or Indian or Chinese science and then be startled to discover that this or that category does not apply. Such is precisely the case of the life sciences, especially biology. We have often been told that the Muslims did not develop a biology such as that which we find in the specifically biological works of Aristotle but were only interested in “applied biology” such as pharmacology and agriculture. This statement is true only if we seek an “Islamic biology” following the modern conception of what biology is. If we do so, then we do not find a great deal of “Islamic biology”, nor for that matter is there much “Chinese biology”. But in Islam, as in China, there is a vast amount of material dealing with biology and the life sciences in general in other forms such as in medical treatises, in works on pharmacology, zoology and botany, in texts of natural history, in literary and philological works and even in writings on philosophy and psychology in the traditional sense (*‘ilm al-naḥs*).

From the Islamic point of view the whole universe is alive and the life sciences really deal with all things. The major distinction is not so much between live and dead matter as it is between different stages, manifestations and degrees of life, which are none other than qualities of universal existence itself on different planes of reality. To speak of life sciences in the matrix of Islamic science is almost to speak of the science of things in general. Even if we seek to limit ourselves to plants and animals, the question of what “life sciences” means is not the same as in the context of modern science. For in Islam the question of “life” is transformed into that of “the moving power” or *anima*; therefore, with Aristotle the Muslim philosophers and scientists focused their attention on psychology as the key to the understanding of life phenomena. For them it was the vegetable soul (*al-naḥs al-nabāṭiyya*) or the animal soul (*al-naḥs al-ḥayawāniyya*) which is responsible for all the features we identify with life in plants and animals. Outside

the study of these general principles, the understanding of animal and vegetable life was sought in zoology and botany respectively. In these fields there was no longer any question of problems of a general biological nature; the problem was to provide a descriptive account of the features of different living forms and their function and use.

Among the Muslim philosophers who developed the theory of the faculties of the vegetable and animal souls, many of the most important were Persian. Al-Fārābī devoted some attention to it; the Ikhwān al-Ṣafā' (Brethren of Purity) spoke extensively of it and Ibn Sīnā gave it its most ample treatment in the sixth book of the physics of his monumental encyclopaedia, *Kitāb al-shifā'*. His view of the faculties of the vegetable and animal souls can be summarized as follows:

vegetable soul (<i>al-nafs al-nabā'iyya</i>)	{	faculty of feeding (<i>ghadhā'iyya</i>) faculty of growth (<i>nāmiyya</i>) faculty of reproduction (<i>muwallida</i>)
animal soul (<i>al-nafs al-ḥayawāniyya</i>)	{	faculty of motion (<i>muḥarrika</i>) faculty of comprehension (<i>mudrika</i>)

The faculty of motion consists in turn of the powers of desire and bodily movement while desire is polarized into the two contradictory but complementary powers of lust and anger, one of which causes attraction and the other repulsion. In this "faculty psychology" and belief in the effusion of the vegetable and animal souls by the "universal or world soul" can be found the basis of the "theory of life" as expounded by the early Muslim thinkers. The appearance of life is not seen as a miracle amidst a sea of dead matter. Rather, beginning with prime matter itself, each stage of terrestrial existence is made possible by the effusion of a new form from the Tenth Intellect, which is the "giver of forms" (*wāhib al-ṣuwar*); and each new stage of life, from the mineral to the plant and from the plant to the animal, is due to the appearance of a new "soul" which is none other than a particular faculty of the universal soul which animates the whole cosmos. The life sciences form an intermediary link in a universal chain that stretches from the minerals to the angels.

In fact the key concept which these early Muslim and Persian philosophers and scientists adopted as the framework for their study of the life sciences was the chain of being (*marātib al-wujūd*). The three kingdoms were for them connected, the lowest animal being a grade above the highest plant and the lowest plant a single stage above the

highest mineral. The qualities and perfections of the different creatures reflected their ontological status in the “great chain of being”. This idea caused much speculation concerning the relation between different living beings both spatially and temporally, and such diverse thinkers as the Mu‘tazilī Naẓẓām, Jābir b. Ḥayyān, Birūnī and the Ikhwān al-Ṣafā’ wrote on the stages of creation and the appearance of different creatures on earth in such a manner that some have misinterpreted them as forerunners of Darwinian evolution. In reality they had in mind gradation rather than evolution and their actual scientific theory was much more akin to that of such natural historians as Cuvier than to the 19th-century evolutionism which cut off the hand of the Creator from creation after the original act.

Sometimes to the central concept of the chain of being was added the correspondence and analogy between the different realms of nature and also between the realms of nature and the archetypal world whose most intelligible symbolism is seen in the world of mathematics. Hence there developed an elaborate science of correspondence between different beings, often linked together by the mathematical symbols connected with each. This “Pythagorean biology” attracted much attention in certain circles of early Shī‘ī thought, where it is often combined with Hermetic and alchemical modes of thinking. The biological sections of the Jābirean corpus provide an example of this type of approach, as do the *Rasā’il* or “Epistles” of the Ikhwān al-Ṣafā’, where mathematical symbolism is closely allied to the morphological and anatomical study of plants and animals.

Yet another major characteristic of the life sciences of this period, which derives directly from Qur’anic inspiration, is the emphasis upon the view that the goal of the study of nature and especially living things is to observe the “signs of God” (*āyāt*) and to derive moral and spiritual benefits from them. Inasmuch as God has shown His “signs” upon the horizon, as the Qur’anic verse “We shall show them Our portents upon the horizons and within themselves until it will be manifest unto them that it is the Truth” (xli. 53, Pickthall translation) testifies, it is the duty of the Muslim to seek to study these signs so that in this way he might gain a greater understanding of Unity (*taḥḥīd*). There was thus a strong religious and spiritual consideration which coloured all studies of the life sciences. The study of nature and especially of living things became combined with a sense of wonder and awe, which we see in so many popular works of natural history,

and which has caused so many of these works to be called '*Ajā'ib al-makhlūqāt*, or "The Wonders of Creation".

This Islamic tendency was fortified by an Indian-Persian tradition of natural history which the Muslims inherited and which differed from the biological tradition of Aristotle and Theophrastus. This Indian-Persian tradition combined moral and religious questions with biological and especially zoological ones. The "Tales of Bidpai", rendered from Sanskrit into Pahlavī and then from Pahlavī into masterly Arabic by Ibn al-Muqaffa' under the title of *Kalīla wa Dimna*, is an excellent example of this kind of study. In this work the habits of animals are studied with the view of learning moral and religious lessons from them and not simply for their own sake. Likewise the chapter on the dispute between man and the animals of the *Rasā'il* of the *Ikhwān al-Ṣafā'*, which became so popular throughout the Muslim world, starts from a study of zoology and leads to a most profound exposition of the spiritual relationship between man and the world of living things. In fact this point of view dominates the whole of the *Rasā'il* and many other works on natural history of the period. Along with the principles stated above it is one of the general characteristics of the approach to the study of life sciences observed in the works composed from the 3rd/9th to the 5th/11th centuries.

IV. NATURAL HISTORY, ZOOLOGY AND BOTANY

The works dealing with the life sciences appear under many different categories. Philosophical works usually have chapters devoted to this theme in those sections which deal with natural philosophy (*tabī'iyyāt*). Medical works such as the *Qānūn* usually begin with general discussions on the meaning of life and death and the functioning of living beings. General geographical descriptions and works on natural history abound with pages concerned with plants and animals. And even literary and religious works from Qur'anic commentaries to philological studies like the works of Abū Ḥanīfa al-Dīnawarī and al-Jāhīz, and popular tales such as the *Sindbād-nāma* and the "Arabian Nights" contain many valuable pages about the knowledge possessed at that time concerning different branches of the life sciences.

The works specifically devoted to natural history from the beginning of the Islamic era to the 5th/11th century are not as numerous as what one observes during the 7th/13th and 8th/14th centuries when most of

the compilations and major zoological treatises such as the *‘Ajā’ib al-makhlūqāt*, *Nuḡbat al-qulūb*, *Hayāt al-ḥayawān* and *Nuḡbat al-dahr* were written. But in this earlier period there are major figures in this domain, leading to al-Mas‘ūdī who has been entitled the “Pliny of the Arabs”. There are also some works dealing with the whole domain of natural history in a manner that is reminiscent of the treatises of the later period. Already in the second Islamic century one can see interest in natural history in the circle associated with the sixth Shī‘ī Imām, Ja‘far al-Ṣādiq, who is in fact himself considered to be the author of several works on natural history. The Jābirean corpus also, which is so closely associated with the Imām’s school, abounds in works dealing with the general field of natural history.

During the 3rd/9th century, while most works in the natural sciences dealt with a specific subject such as zoology or botany, there appeared a strange work entitled *Sirr al-asrār*, “Secretum Secretorum” in its well-known Latin translation, and attributed to Aristotle. Actually this work is probably of Syriac origin, and reflects the late Sāsānian and also Hellenistic “science of the property of objects” (*ḵhawāṣṣ al-aṣhyā’*, *physikai dynamis* of the Alexandrian school), which combines a physiognomic, magical and occult interest in the properties of natural objects with the more usual type of natural history. This type of “science” is closely connected with Hermeticism and had its centre in both Syria and Persia and especially in Marv just before the rise of Islam. It entered into many works of natural history in Arabic, and through the translation of these works into Latin and even Catalan and other European languages, exercised an appreciable influence upon the “magical school” of natural history in the West. There must have developed a whole school in the late Sāsānian period in Persia and the surrounding regions devoted to this study of the occult properties of objects, of which little trace remains beyond the few works such as the “Secretum Secretorum” that suddenly appears in the 3rd/9th century and exerts so much influence upon a particular school of Muslim natural historians.

There are other figures in the domain of natural history in this early period such as Ibn Qutaiba whose *‘Uyūn al-aḵbār* contains a wealth of knowledge on the subject. But the outstanding natural historian of this age is Abu’l-Hasan al-Mas‘ūdī (d. 345/957), who has been compared so often to Pliny. Combining first-hand knowledge of geography attained through extensive travels in Western and Central Asia, India

and the Indian Ocean with a philosophical and theological training, he wrote works on natural history that contain elements of history, geography, geology, botany and zoology. His two major works, *Murūj al-dhahab* and *al-Tanbīh wa'l-ishrāf*, which summarize his views, are perhaps the most outstanding works on natural history in the 4th/10th century.

Actually as a historian al-Mas'ūdī was following the tradition of the universal histories of Ṭabarī and al-Ya'qūbī, and as a geographer, the well-known works of al-Khwārazmī, Ibn Khurdādbih, the philosopher al-Kindī, al-Balkhī and al-Iṣṭakhṛī. But the distinguishing feature of his works was to emphasize the aspect of natural history. Of course both the Muslim universal histories and many of the geographies contain pages devoted to natural history, but in them there is not the same concentration upon natural phenomena, the acute observation of flora and fauna, and of minerals and geological formations that one finds in al-Mas'ūdī. It is because of these features that the works of al-Mas'ūdī are usually classified with those on science and natural history rather than with those on pure history.

Zoology

The early Muslim treatises on zoology are all in Arabic and are closely associated with philological considerations, as is seen in the works of al-Aṣma'ī and al-Jāḥiẓ. But already in the *Kitāb al-ḥayawān* of al-Jāḥiẓ there are many elements of earlier Persian animal lore. The *Kalīla wa Dimna*, made popular in Arabic through Ibn al-Muqaffa', had made known the Indian and Persian animal lore, which combined scientific and moral interests so closely. This moral concern with animals, which at the same time reveals intimate knowledge of their behaviour, is reflected in much of the literature of the day, even in the "Arabian Nights", many of whose pages reveal specifically Persian elements. It remained, however, for a 7th/13th-century author, al-'Aufī, to write the *Jawāmi' al-ḥikāyāt* ("Collected Stories") which is the most famous Persian literary work dealing with animals.

The early centuries saw a few specifically zoological works such as the *Ṭabāyī' al-ḥayawān* ("Nature of Animals") of the 5th/11th-century author Abū Sa'īd b. Bukhtyishū', and several treatises on different birds and domestic animals. The most important zoological discussions of the period appear in medical and philosophical works where studies are made of the anatomy and physiology of animals. Sections of Ibn Sīnā's

Qānūn dealing with the general nature of animals and their constitution and especially the eighth book of the physics of his *al-Shifā'* illustrate this type of writing. The latter work is probably the most important theoretical work on zoology of the period, continuing the tradition of Aristotle and Galen.

Altogether, however, the interest of Persians like other Muslims in zoology was more practical than theoretical. It either involved moral and spiritual lessons as we see in the *Rasā'il* of the Brethren of Purity and the *Kalīla wa Dimna*, or medical properties of animal parts and extractions as we see in the pharmacological treatises, or their agricultural use as is seen in treatises on agriculture. Even works dealing with a single animal are often concerned with its specific use as in hunting, as we see in some of the well-known works on falconry of later centuries. An important example of this kind, as far as the Persian language is concerned, is the *Bāḡ-nāma* of Abu'l-Ḥasan 'Alī b. Aḥmad Nasawī, a student of Ibn Sīnā and an acquaintance of Bīrūnī. Nasawī, who is also known for his mathematical works, composed the *Bāḡ-nāma*, which deals with birds used for hunting, in Persian, basing himself on earlier works of different nations especially the Persians. The treatise indicates the strong interest of Persians in this subject going back to the Sāsānian period, and is itself a fine example of treatises on hunting birds, of which many more are to be found during later centuries.

Treatises on zoology, even when studied philosophically, are concerned more with animals within the total scheme of things, in view of their rôle in the great chain of being and the necessity of their existence to complete the total plan of the Universe. The study of zoology, like botany, was never completely anthropomorphic as one might think. Rather, it was always teleological and aimed at a purpose, whether that be material or spiritual. For in Islamic science there has never been "science for science's sake". Science in Islamic civilization has always been studied with a certain end in view, whether that end be intellectual or material. All the sciences cultivated in Persia at this time and especially zoology and botany conform to this general principle.

Botany and Pharmacology

In botany, as in zoology, one must search in many fields to gather information. Knowledge from the many domains in which the study of plants was carried out must be brought together so as to reveal the

contours of this science as it developed among Muslims. Botany was studied from the point of view of natural history and geography, agriculture, philology and literature and most important of all pharmacology, not to speak of theoretical botany which was connected with general studies in natural philosophy (*ṭabīʿiyyāt*) as we find in the *Shifāʾ* and the *Rasāʾil* of the Ikhwān al-Ṣafāʾ. Most of the study of plants was connected with their properties and application to different fields, especially medicine. That is why medical texts, in both Arabic and Persian, are among the most important sources for our knowledge of botany and pharmacology. The field of medicine is inseparable from the study of the plant sciences. In fact the Muslims concentrated so much on vegetable rather than mineral and animal drugs that pharmacology became almost completely an applied botany, and so it is treated here along with botany rather than with medicine where it naturally belongs.

Interest in philology and search for the root of plant names was responsible for many early works in botany which combined philological and scientific interests, in the same way that al-Aṣmaʿī and al-Jāḥiẓ pursued the field of zoology with a literary and philological motive. The Persians already possessed much agricultural and botanical knowledge before the rise of Islam, and many plant names in Arabic are to this day of Persian origin. There were also plants whose nomenclature was of Babylonian, Greek and Nabataean origin. This led to the need for extensive research on the origin of plant names and ultimately to a study of their morphology and properties which reached its peak in the Maghrib and Spain with al-Ghāfiqī and Ibn al-Baiṭār.

Of the early writers of Persian origin or background who devoted themselves to this type of philological study one can mention Hishām b. Ibrāhīm al-Kirmānī, author of *Kitāb al-nabāt*; Abū Ḥātim al-Sijistānī, author of *Kitāb al-ẓarʿ* and many zoological treatises; Abū Ḥanīfa al-Dīnawarī, author of the most famous early Muslim work on botany of a lexicographical character, also entitled *Kitāb al-nabāt*, which is a precious document for early Muslim knowledge of botany and in which is collected oral and written Arabic traditions of botany as well as much material of Persian origin in Arabic; Ibn Duraid who composed the well-known *Kitāb al-jamhara* containing many plant names; Ibn Khālūya of the court of Saif al-Daula, who wrote the *Kitāb al-shajar* and several other works devoted to plants; and Majd al-Dīn Fīrūzābādī whose *al-Qāmūs al-muḥīṭ* is an authoritative dictionary containing a

wealth of information on plants. Many other of the grammarians and philologists of Baṣra and Kūfa could also be included since in one way or another they were in contact with the sphere of Persian culture.

In the domain of agriculture the basis of early Muslim works in this field is as much Persian as Byzantine, and at the same time it is to a certain extent Roman and Nabataean. While, however, the "Geoponica" literature, especially the work of Cassianus Bassus, and the "Nabataean Agriculture" of Ibn Waḥshiyya are known by name, the works of Persian origin have remained mostly anonymous as in so many other cases. Their existence can only be traced through their influence on early works in Arabic and also through the testimony of the actual practice of agriculture in such provinces as *Khurāsān*, which was certainly the continuation of Sāsānian practices. There has survived the manuscript of a work on agriculture, the *Barḡ-nāma*, dealing with Persian agriculture and indicative of the type of agricultural knowledge prevalent at that time.

Among geographers and travellers interest in the flora and fauna of different regions was always strong and in most works of this kind there are sections devoted to plants. The first Muslim geographer to have written on plants was Ibn Wādiḥ al-Ya'qūbī followed soon by Ibn Rusta. After that most of the standard authors on geography such as Ibn Ḥauqal and Ibn *Khurdābih*, as well as travellers like Bīrūnī in his "India" and Nāṣir-i *Khusrāu* in his "Travels" did not fail to mention something of the plants of each region they described. As a result, the works of geography serve as a valuable source for our knowledge of botany, and most Muslim geographers, especially the later ones like al-Idrīsī, must be also considered as botanists.

It is especially in the field of pharmacology that Muslim scientists excelled, to the extent that recently an authority could write, "In pharmacology and pharmacognosy, the medieval Islamic peoples far surpassed the Greeks and Latins."¹ The Persians were already well-versed in pharmacology in the Sāsānian period, as witnessed by the large number of Persian names for drugs, especially in compounds. They continued this tradition into the Islamic period when the level of knowledge of pharmacology far surpassed what was known by Theophrastus and Dioscorides. This tradition in fact reached its peak much later in the Ṣafavid period, which has been called the "golden age of pharmacology".

¹ M. Levey, p. 3.

The Muslims divided drugs into simples (*mufradāt*) and compounds (*murakkabāt*). Drugs were also called 'aqāqīr, and the treatises dealing with them were of several types: books on poisons, lists of *materia medica*, synoptic treatises and *Aqrābādhīn*, from the Greek γραφίδιον, meaning a list or registry of drugs or prescriptions. Most Muslim medical treatises, such as the *Qānūn* of Ibn Sīnā, contain elaborate sections devoted to this subject, and there are independent works known by this name such as those of Ibn al-Tilmīdh and Samarqandī that have been famous throughout Islamic history.

The earliest *Aqrābādhīn* is, however, that of Yuḥannā b. Māsūya (Māsawaih), which was later translated into Latin by Pietro d'Abano and which gained for the author the title *pharmacopoeum evangelista*. Of greater fame is that of Sābūr b. Sahl of Jundīshāpūr. The philosopher al-Kindī was also interested in plants and wrote an *Aqrābādhīn* as well as other treatises on drugs and perfumes. The philosopher-physician Rāzī also composed a well-known *Aqrābādhīn* which was later rendered into Hebrew and Latin, while Ibn Sīnā has left a most complete formulary of drugs in the *Qānūn* that is still in use in certain regions of the East. His contemporary philosopher and historian Ibn Muskūya (Ibn Miskawaih) also left behind a *Kitāb al-mufradāt*.

As far as the Persian language is concerned the work on drugs by Abū Maṣṣūr Muwaffaq b. 'Alī al-Hirawī entitled *Kitāb al-abniya 'an ḥaqā'iq al-adwiya* ("Book of the Foundations of the True Properties of the Remedies"), written between 357/968 and 366/977, is particularly important because it is among the first extant prose works of the Persian language. The author mentions 585 remedies, drawing from Greek, Syriac, Persian and Indian as well as Arabic sources. There is also a general theory of drugs developed which is of scientific interest. But the greatest interest that attaches to this work is from the point of view of the Persian language itself, for Hirawī presages the many future authors like Jurjānī who were to write extensive medical treatises in Persian from the 6th/12th century onward.

Also of particular significance in the field of pharmacology during this period is the *Kitāb al-ṣaidala* ("Book of Drugs") of Bīrūnī, which has not been edited as yet. Like other works of the author, this treatise is a masterpiece of its own, and it was later translated into Persian by Abū Bakr b. 'Alī b. 'Uṭhmān Aṣṣāf al-Kāshānī. Bīrūnī, while employing Babylonian, Greek, Syriac, Indian and Arabic sources, draws especially from earlier Persian works many of which are now lost. Besides its

intrinsic value as perhaps the most authoritative work of its kind of the period, the *Kitāb al-ṣaidala* is also an important source for our knowledge of the earlier tradition of Persian pharmacology.

Besides the *Aqrābādihīn*, another type of work on pharmacology which is of much interest is that dealing with poisons. This particular subject, like several other branches of pharmacology, drew heavily from Indian sources. The books on drugs were in fact often called *Kunnāsh* ("Pandects"), which is derived from Sanskrit. But in poisons more than elsewhere the elaborate Indian writings show their clear influence. Like the Indians, the Muslims were fascinated by the different ways in which poison could be administered, and men in power as well as physicians were interested in gaining knowledge of different forms of poisons as stories such as the "Arabian Nights" amply demonstrate. Among the important works on this subject is the *Kitāb al-sumūm* ("Book of Poisons") of Jābir b. Ḥayyān. Equally well known is that of Ibn Waḥshiyya. In both cases the close rapport between this branch of pharmacology and the occult property of things can be seen through the names of the two authors, who are among the most famous in Islam to have written on the hidden and occult nature of substances.

V. GEOLOGY AND MINERALOGY

Although geology and mineralogy are not a part of the life sciences, they form an integral part of natural history and, in the context of Islamic science, cannot be separated from the study of zoology and botany. In geology, Muslim authors usually based their theoretical discussions on the works of the Greek natural historians and geographers, but made many original observations not found in earlier sources. There are descriptions in al-Mas'ūdī which indicate direct observation. Of even greater interest is Bīrūnī's description of the sedimentary basin of the Indian sub-continent, found in his "India", and Ibn Sīnā's theories of rock formation and mountain structure as well as his close study of the nature of sedimentary deposits and analysis of meteorites. Many geological phenomena such as diastrophism, tectonic movements and mineral genesis are described by the early Muslim geologists in a manner that is confirmed by current theories and observations.

An important description repeated in the writings of many authors of this period is that of fossils, which the Brethren of Purity and Bīrūnī describe correctly as remains of animals of earlier ages. Unlike the

mediaeval West where up to the 18th century fossils remained essentially a mystery, Muslim authors regarded the presence of fossils even on mountain tops as only confirming their theory of cycles separated by cataclysms, a theory somewhat reminiscent of those of Cuvier and other 18th-century Occidental naturalists. There was also a keen awareness of the greater complexity of life forms in later geological ages, but never a theory of evolution in the Darwinian sense, for this would be absurd from the point of view of any metaphysics, the Islamic included.

In mineralogy, the theoretical aspect was closely tied to alchemy, which will be treated later, and even those like Ibn Sīnā who did not believe in alchemical transformations accepted the alchemical sulphur-mercury theory of the structure of minerals and metals. The standard works on mineralogy, however, dealt more with the properties of minerals than with their constitution. The earliest texts of this kind include the *Manāfi' al-ahjār* of 'Uṭarid b. Muḥammad al-Ḥāsib, cited often by Rāzī and other later authorities, and the *Khawāṣṣ al-ahjār* and the *al-Ahjār*, attributed to Hermes and Aristotle respectively. The *al-Ahjār* or "Lapidary" of Aristotle, which became well known in the mediaeval period, belongs definitely to the late Sāsānian Persian-Syriac tradition and differs from the "Mineralogy" of Theophrastus. It is certainly an Oriental compilation and contains many Iranian names for stones. Later works of this kind, that is those concerned primarily with the description of stones and their properties, include the *Nuḥbat al-nufūs wa'l-afkār fī khawāṣṣ al-mawālīd al-thalātha*, *al-Jauharatain al-'aḳiqatain* of Abū Muḥammad al-Hamadḥānī and *al-Aghrād al-ṭibbiyya* of Jurjānī. It is this same tradition which led to the later well-known works on precious stones such as the *Jawābir-nāma* attributed to Naṣir al-Dīn Ṭūsī and the *'Arā'is al-jawābir* of Abū'l-Qāsim Kāshānī.

The most important Muslim lapidary of the pre-Saljuq period is without doubt the *Kitāb al-jawābir fī ma'rifat al-jawābir* of Bīrūnī. This masterpiece of descriptive mineralogy brings together a great deal of information on different stones, combining matters of mineralogical and philological interest. Moreover, the work makes use of such earlier sources as the books of al-Kindī and Naṣr b. Ya'qūb al-Dīnawarī on precious stones that have been lost.

A book contemporary with the above-mentioned works and representing the summit of mineralogy in its analytical rather than descriptive aspect is the "De Mineralibus" of Ibn Sīnā, long considered as a treatise of Aristotle in the West. This well-known work was originally

GEOLOGY AND MINERALOGY

the fifth section of the physics of the *Shifā'*, which deals with the mineral kingdom within the larger context of Ibn Sīnā's natural philosophy. In its Latin translation, however, it became an independent book that completed in Western eyes Aristotle's treatment of the three kingdoms. In describing the constitution of metals and minerals and their place in the natural order this work is as important as the *Jawāhir* of Bīrūnī, which seeks mostly to describe the qualities and properties of minerals rather than their constitution and place in the hierarchy of existence.

VI. ALCHEMY

The tradition of Islamic alchemy, in Persia as in other parts of the Islamic world, is closely related to the Alexandrian school while at the same time certain links with China can be discerned in many domains, especially in the relation between magic squares and alchemical doctrines. Islamic alchemy, like the alchemy which preceded it in Alexandria and China and the school that followed it in the West, is not a crude chemistry. It is rather a science of the soul based on the symbolism of metals and at the same time on the correlation between the microcosm and the macrocosm, or the operations of nature and those which occur within the soul of man. Its perspective belongs to the period when spirit and matter had not as yet become wholly separated and the sacred was still intimately connected with the symbolic significance of natural phenomena. Alchemy was a way to ennoble matter. It was both a science and a technique, concerned at once with psychology, cosmology and art. It bestowed a spiritual significance upon the work of the artisan and served as a means to achieve spiritual perfection within the cosmic order itself by making use of cosmic and natural forces. The link between Ṣūfism and the craft guilds must be sought in many instances through alchemy, which provided both a symbolic language for Ṣūfīs and an operational method for the artisan. From this tradition through the gradual loss of the "symbolist vision" there grew the science of chemistry which is concerned solely with the material aspect of things. Some of the Muslim alchemists undoubtedly did perform actual experiments with metals and minerals and in fact developed much of the apparatus used for centuries and even now in chemistry laboratories, but their vision was hardly ever limited to the material aspect of substances alone. The colours, forms and material transformations continued to convey a symbolic significance for them. That is

why alchemy is a field that is at once concerned with Ṣūfism, cosmology, a traditional and sacred psychology and art as well as chemistry, pharmacology and medicine. It was moreover, the way in which the spirit of Islam was able to penetrate the material environment in which it breathed and to leave upon it its imprint.

The origin of Islamic alchemy is associated with Alexandria and the names of Morianus and Khālīd b. Yazīd. But there were also definite Persian and Mesopotamian influences present, not to speak of certain Chinese factors, which appear fully in the works of Jābir b. Ḥayyān. Alchemy definitely was widely spread in Sāsānian Persia, and the rôle of the school of Jundishāpūr in the transmission of this art cannot be in any way neglected. In fact E. J. Holmyard, one of the foremost scholars of the history of alchemy, states that the "fundamental ideas [of alchemy] arose in the ancient Persian Empire, which includes Mesopotamia, Asia Minor, Syria and Egypt".¹ Although there is little knowledge of Sāsānian alchemy, traces of this tradition can be seen in the works of certain later Muslim alchemists, especially Rāzī, whose frequent reference to *nushādūr* many scholars such as Ruska have seen as proof of Sāsānian alchemical influence in his works. The coming of Islam brought the different centres of alchemical knowledge and practice together and fused the several different schools of the ancient world, especially the Alexandrian, with the Chinese and Persian and also perhaps Indian into a synthesis which is seen in the Jābirean corpus.

Mystery still shrouds the identity and personality of the founder of Islamic alchemy, Jābir b. Ḥayyān. Some have even doubted his existence, while others like Kraus have cast doubt upon the authenticity of the works attributed to him. But when all the evidence is examined, it is hardly possible to doubt that such a person existed, that he was an alchemist and that he also belonged to the circle of the sixth Shī'ī Imām, Ja'far al-Ṣādiq. It is also clear that some of the works in the Jābirean corpus are later accretions of Ismā'īlī inspiration. There is a link between Jābirean alchemy and Ismā'īlism in such works as the *Kitāb al-mājid* ("The Book of the Glorious"), and also many links with the general tradition of Ṣūfism in such questions as the symbolism of letters.

Jābir is entitled in traditional sources as al-'Azdī, al-Kūfī, al-Ṭūsī, al-Ṣūfī. There is a debate as to whether he was an Arab from Kūfa who

¹ E. J. Holmyard, "Alchemical Equipment" in *A History of Technology*, ed. E. Singer *et al.*, vol. II (Oxford, 1957), p. 731.

lived in Khurāsān, or a Persian from Khurāsān who later went to Kūfa, or whether he was, as some have suggested, of Syrian origin and later lived in Persia and Iraq. What remains certain is that he and his family lived much of their life in Ṭūs in Khurāsān, that he spent a good part of his life, which stretches over the 2nd/8th century, in Kūfa and at the court of Hārūn al-Rashīd in Baghdad, that he was a Ṣūfī, and that he was also in the circle of Imām Ja‘far. Recently some have claimed to have discovered his tomb in western Persia. He was both the founder of Islamic alchemy and the prototype of the Muslim alchemist in later centuries.

The works of Jābir deal not only with alchemy but also with cosmology, psychology, natural philosophy and even the science of language. In alchemy they contain a whole philosophy of nature dominated by the idea of the “balance” which symbolizes the harmony of various tendencies of the world soul. There is also a great deal of chemistry and the descriptions of such processes as the preparation of nitric acid and compounds of copper. The alchemical descriptions are dominated by the sulphur–mercury theory of the structure of metals which became known to the West in the writings of the Latin Geber. There is also a great deal of emphasis upon the elixir (*al-iksīr*), a term which Jābir uses for the first time in its specifically alchemical sense. For Jābir *iksīr* and *kīmiyā’* (from which comes the term alchemy) mean nearly the same thing. Both signify the agent causing transmutation rather than transmutation itself.

Two fundamental alchemical texts that appeared soon after Jābir are the *Sirr al-khalīqa*, probably of Syriac origin, written during the reign of al-Ma’mūn and at the end of which appears the famous “Emerald Table”, and the “Turba Philosophorum” by the Egyptian alchemist, ‘Uthmān b. Suwaid. These works bridge the gap between Jābir and Muḥammad b. Zakariyyā’ al-Rāzī, the Latin Rhazes, who was his real successor in alchemy. Rāzī held a different view about religion and nature from Jābir and in fact opposed the fundamental Shī‘ī doctrine of hermeneutic interpretation or *ta’wīl*, through which the Shī‘ī and Ṣūfīs seek to penetrate into the inner meaning of both revelation and natural phenomena. And in so doing Rāzī converted alchemy into a science of material substances or chemistry. Yet, his alchemical writings follow the titles of the works of Jābir and he was profoundly influenced by him, except that he had no interest in the Jābirean balance. He still moved in the atmosphere of Jābirean alchemy; “A study of Razi’s writings, however,

conveys the impression that he was much more interested in practical chemistry than in theoretical alchemy.”¹

The best-known works of Rāzī on alchemy include his *Sirr al-asrār* (“Secret of Secrets”) and the *Asrār* (“Secrets”) which has until recently been mistaken for the *Sirr al-asrār*. The *Asrār*, edited by Ruska as *Sirr al-asrār*, contains descriptions of alchemical apparatus and reveals clearly Rāzī’s concern with laboratory work and experimentation. Rāzī described many substances, animal, vegetable and mineral alike, and in fact he is the first to have classified substances into these categories. He also described many chemical processes, such as calcination. The writings of Rāzī must be considered as the first documents of chemistry, although still shrouded in the language of alchemy.

The tradition of alchemy continued in Persia after Rāzī as we see in the writings of Qāḍī ‘Abd al-Jabbār, a Mu‘tazilī who wrote the *Risāla fi’l-kīmiyā* (“Treatise of Alchemy”), and Abu’l-Hākim Muḥammad al-Kāthī, author of the *Ain al-ṣan‘a wa ‘aun al-ṣinā‘a* (“Origin of the Art”). In later centuries, most of the authors continued to rely on the writings of the early masters, especially Jābir and Rāzī, who in fact brought Islamic alchemy to its peak early in its career. Alchemy continued to survive both as an operational science connected with the crafts and a mystical science of the soul attached to Ṣūfism, in which form it has continued to produce works of note from the alchemical treatise of Mīr Findiriskī in the Ṣafavid period to the alchemical poems of the Qājār Ṣūfī poet, Muḥaffar ‘Alī Shāh.

VII. MEDICINE

The major link between Islamic and Greek medicine must be sought in late Sāsānian medicine, especially in the School of Jundīshāpūr rather than in that of Alexandria. At the time of the rise of Islam Jundīshāpūr was at its prime. It was the most important medical centre of its time, combining the Greek, Indian and Iranian medical traditions in a cosmopolitan atmosphere which prepared the ground for Islamic medicine. The combining of different schools of medicine foreshadowed the synthesis that was to be achieved in later Islamic medicine, and the practices and institutions then established influenced much that is seen several centuries later in Baghdad and other centres of Islamic civilization. “To a very large extent the credit for the whole hospital system must be given to Persia. The hospitals of the Mohammadan period

¹ E. J. Holmyard, *Alchemy*, p. 86.

were built very largely upon the ideals and traditions of the Sāsānian hospital of Jundīshāpūr.”¹ The well-known hospitals of ‘Aḍud al-Daula in Shīrāz and Baghdad, as well as the later hospitals of Damascus and Cairo, were based upon the Jundīshāpūr model. The first products of Islamic medicine were also from this important medical centre.

Although one of the Companions of the Prophet, Ḥārith b. Kalada, studied at Jundīshāpūr, the earliest medical figures in Islamic history were Christians and Jews, the most outstanding among them being Ḥunain b. Ishāq, to whom we owe the best translations of the Hippocratic and Galenic corpus and also major independent treatises on medicine. The physicians of the caliphs continued to be Christians and Jews until the time of the caliph al-Mu‘taḍid who had a Persian Muslim physician, Aḥmad b. al-Ṭayyib al-Sarakhsī. Among the Christians also there were some of Persian origin or at least of immediate Persian background, among whom the most important are the Bukhtyishū‘ and Māsūya (Māsawaih) families. The members of the Bukhtyishū‘ family were directors of the Jundīshāpūr hospital and produced many outstanding physicians. One of them, Jirjīs, was called to Baghdad by the ‘Abbāsid caliph al-Manṣūr, to cure his dyspepsia. Due to his success he became court physician of the caliphs, and after him the whole school was transferred to Baghdad marking the real beginnings of Islamic medicine. As for the Māsūya family, the father was a person of definite genius who gained knowledge of medicine through experience in the hospital of Jundīshāpūr without formal training. He later came to Baghdad at the time of Hārūn al-Rashīd to seek fame and fortune. All his three sons became physicians. Among them Yuḥannā b. Māsūya (the Latin “Mesue Senior”) is best known. In fact he was the outstanding physician in Baghdad during the first half of the 3rd/9th century, was the first in Islamic civilization to perform dissection of animals and wrote the first Arabic treatise on ophthalmology. Also of importance among the early physicians of the Persian world at this time are Sābūr b. Sahl of Jundīshāpūr and Yaḥyā b. Serapion.

From the 3rd/9th century onward Muslims themselves began to cultivate interest in medicine and henceforward became the main figures in the history of medicine. The greatest of these figures, who ushered in the golden age of Islamic medicine and who are discussed separately by E. G. Browne in his *Arabian Medicine*, are four Persian

¹ C. Elgood, p. 173.

physicians: 'Alī b. Rabban al-Ṭabarī, Muḥammad b. Zakariyyā' al-Rāzī, 'Alī b. al-'Abbās al-Majūsī and Ibn Sīnā. These four figures dominated the scene during the two centuries stretching from the 3rd/9th to the 5th/11th, overshadowing other figures of significance such as Abu'l Ḥasan Aḥmad b. Muḥammad al-Ṭabarī, the author of *al-Mu'ālajāt al-buqrāṭiyya*; Abū Bakr Rabī' al-Akhwīnī al-Bukhārī, the student of Rāzī who is the author of the oldest known Persian medical text, entitled *Hidāyat al-muta'allimīn fi'l-ṭibb*; Abū Maṣṣūr b. al-Ḥasan al-Qamarī, the teacher of Ibn Sīnā in medicine; and Abū Sahl 'Īsā b. Yaḥyā al-Jurjānī, whose *Kitāb al-mī'a fi'l-ṣinā'at al-ṭibbiyya* served as a model for Ibn Sīnā's "Canon".

'Alī b. Rabban al-Ṭabarī, who was a convert from Zoroastrianism to Islam, is the author of the first major work on Islamic medicine, entitled *Firdaus al-ḥikma* ("The Paradise of Wisdom"). The work combines the Hippocratic and Galenic traditions of medicine and is also of particular interest for its last section, devoted to Indian medicine. The value of the book lies especially in its treatment of pathological and pharmacological questions.

Ṭabarī was the teacher of the real founder of clinical medicine in Islam, Rāzī. This great scientific figure of the 4th/10th century devoted the earlier part of his life to the study of alchemy, music and philosophy and became attracted to medicine only in the later period of his life. Yet his mastery in this domain became so great that soon he became the head of the hospital in Ray and later the chief director of the hospital in Baghdad. Long experience with different patients helped make Rāzī an outstanding authority in observation and prognosis. In fact he is probably the greatest clinical physician of Islam. His magnum opus, the *al-Ḥāwī* (translated into Latin as "Continens"), is the most precious existing document on clinical medicine in Islam and bears testimony to the author's mastery in observation. Rāzī wrote altogether fifty-six works on medicine and related subjects of which, after the *al-Ḥāwī* the most important in the history of medicine are the *Kitāb al-manṣūrī*, also rendered into Latin, and his small masterly treatise on smallpox and measles, *Kitāb al-jadarī wa'l-ḥasba*, published along with several other of his shorter works in Latin as "Opera Parva Abubetri" and translated later into several European languages.

Rāzī was the first to describe smallpox, and the first to write an independent treatise on pediatrics. He is usually credited with the isolation of alcohol and its use in medicine as an antiseptic, and also the

use of mercury as a purgative. The "Album Rhasis" of the Latin Middle Ages is named after him. Altogether Rāzī had a profound influence in both East and West and is, after Ibn Sīnā, the most influential of all Muslim physicians.

Between Rāzī and Ibn Sīnā the outstanding medical figure was 'Alī b. 'Abbās al-Majūsī al-Ahwāzī, of whom little is known save that he was the physician of 'Aḍud al-Daula and came from Ahwāz or possibly Bihbahān. His masterpiece, *Kāmil al-ṣinā'a* or *Kitāb al-malikī*, known in the West as "Liber regius", is the outstanding work after *al-Ḥāwī* and became a standard medical text until the appearance of Ibn Sīnā's "Canon". Ahwāzī studied medicine with Abū Māhir Mūsā b. Sayyār al-Qummī and was well acquainted with both the Greek and earlier Muslim authorities. He knew Rāzī well and criticized *al-Ḥāwī* for its disorderliness. His own *Kitāb al-malikī* is known for its organization and order. It is divided into two main sections devoted to theoretical and practical medicine respectively, and each section is in turn subdivided into ten chapters. Of particular significance is the chapter on surgery, which is the most original part of the work. The last chapter is devoted to pharmacology and is also of much interest.

After Ahwāzī there were many physicians of note, especially Abū Sahl 'Īsā b. Yaḥyā al-Masīḥī al-Jurjānī, who was a contemporary of Ibn Sīnā and perished during the flight with Ibn Sīnā to Khurāsān. But his name, like that of all other physicians of the latter half of the 4th/10th century was overshadowed by the towering figure of Ibn Sīnā, who is the most influential medical figure of the mediaeval period in both East and West. Ibn Sīnā was already a well-known physician at the age of eighteen and did not cease to practice until his death. He combined the acute observational powers of the earlier physicians with a philosophical mind that sought to create a philosophy of medicine and of living things in general, as we find in the first book of his "Canon". He was in a sense Hippocrates and Galen combined in a single figure. His observations led to the discovery of specific illnesses and their correct description, as in the case of meningitis, described correctly for the first time by him. His knowledge of the human psyche led to a remarkable development of psychosomatic medicine in his hands. But perhaps most important of all, his philosophical mind succeeded in creating a philosophy of medicine which is still of much value.

Ibn Sīnā wrote one great medical masterpiece, the *Qānūn* or "Canon", which has remained the best-known medical work in the East, is still

studied and consulted by *ḥakīms* today, and was known almost to the same extent in its Latin translation in the West. This monument of Islamic medicine is the synthesis of all that came before and the basis of all that followed. Ibn Sīnā also wrote shorter medical treatises such as the *Urjūza* or “Poem of Medicine” and the treatise on the pulse, *Dānish-i rag* or *Nabḍiyya*, in Persian, which is particularly important for its being one of Ibn Sīnā’s definitely authentic Persian works. His concern in medicine ranged from pharmacology to psychology, and he established a school which is among the major medical systems of the world and is still of value in many fields of medicine.

After Ibn Sīnā, Islamic medicine acquired a more local character. One can discern for example an Andalusian and Moroccan school, an Egyptian school or a Persian one. The latter begins to use the Persian language more frequently. The *Dhakhira-yi Khwārazmshāhī* of Jurjānī, a vast medical encyclopaedia in Persian, is based on the *Qānūn*, as are the many works produced in Ṣafavid Persia and Moghul India. Thus, in medicine as in the life sciences, the first few Islamic centuries produced many prominent figures, most of them connected in one way or another with the Persian climate, who determined the nature and future course of the Islamic sciences.

BIBLIOGRAPHY

Volume Editor's Note

The bibliographies printed below are selective and not intended to be complete; in general they include those works used by each author in the preparation of his chapter. It has not been possible to check the source references of all authors, especially where rare editions of texts have been used. As a rule books and articles superseded by later publications have not been included.

The abbreviations and short titles used in the bibliographies are listed below.

<i>AA</i>	<i>Arts asiatiques</i> (Paris)
<i>AESC</i>	<i>Annales: économies, sociétés, civilisations</i> (Paris)
<i>AGNT</i>	<i>Archiv für die Geschichte der Naturwissenschaften und der Technik</i> (Leipzig)
<i>AGWG</i>	<i>Abhandlungen der königlichen Gesellschaft der Wissenschaften zu Göttingen</i> (Berlin)
<i>AI</i>	<i>Ars Islamica</i> (Ann Arbor, Mich.)
<i>AIEO</i>	<i>Annales de l'Institut d'Études Orientales</i> (Paris–Algiers)
<i>AIUON</i>	<i>Annali, Istituto Universitario Orientale di Napoli</i> (Naples)
<i>AJSLL</i>	<i>The American Journal of Semitic Languages and Literatures</i> (Chicago)
<i>ANS</i>	American Numismatic Society
<i>ANSMN</i>	<i>American Numismatic Society Museum Notes</i> (New York)
<i>ANSNNM</i>	<i>American Numismatic Society Numismatic Notes and Monographs</i> (New York)
<i>ANSNS</i>	<i>American Numismatic Society Numismatic Studies</i> (New York)
<i>AO</i>	<i>Ars Orientalis</i> (continuation of <i>Ars Islamica</i>) (Ann Arbor, Mich.)
<i>BAIPAA</i>	<i>Bulletin of the American Institute for Persian Art and Archaeology</i> (New York)
<i>BGA</i>	<i>Bibliotheca Geographorum Arabicorum</i> , 8 vols. (Leiden)
<i>BIFAO</i>	<i>Bulletin de l'Institut Français d'Archéologie Orientale</i> (Cairo)
<i>BSOAS</i>	<i>Bulletin of the School of Oriental and African Studies</i> (London)
<i>EI</i>	<i>Encyclopedia of Islam</i> (Leiden)
<i>GMS</i>	“E. J. W. Gibb Memorial” series (Leiden–London)
<i>IA</i>	<i>Iranica Antiqua</i> (Leiden)
<i>IC</i>	<i>Islamic Culture</i> (Hyderabad)
<i>IQ</i>	<i>Islamic Quarterly</i> (London)
<i>Iran</i>	<i>Iran</i> (journal of the British Institute of Persian Studies) (London–Tehrān)
<i>Iraq</i>	<i>Iraq</i> (journal of the British School of Archaeology in Iraq) (London)

BIBLIOGRAPHY

- | | |
|------------------|--|
| <i>IS</i> | <i>Islamic Studies</i> (journal of the Central Institute of Islamic Studies, Karachi) (Karachi) |
| <i>Der Islam</i> | <i>Der Islam</i> (Zeitschrift für Geschichte und Kultur des Islamischen Orients) (Berlin) |
| <i>JA</i> | <i>Journal asiatique</i> (Paris) |
| <i>JAOS</i> | <i>Journal of the American Oriental Society</i> (New York) |
| <i>JESHO</i> | <i>Journal of Economic and Social History of the Orient</i> (Leiden) |
| <i>JNES</i> | <i>Journal of Near Eastern Studies</i> (continuation of <i>American Journal of Semitic Languages</i>) (Chicago) |
| <i>JRAS</i> | <i>Journal of the Royal Asiatic Society</i> (London) |
| <i>JSS</i> | <i>Journal of Semitic Studies</i> (Manchester) |
| <i>MRASB</i> | <i>Memoirs of the Royal Asiatic Society of Bengal</i> (Calcutta) |
| <i>MSOS</i> | <i>Mitteilungen des Seminars für orientalische Sprachen</i> (Berlin) |
| <i>MW</i> | <i>Muslim World</i> (Hartford, Conn.) |
| <i>NC</i> | <i>Numismatic Chronicle</i> (London) |
| <i>NHR</i> | Miles, G. C. <i>The Numismatic History of Rayy</i> . New York, 1938 (ANSNs, vol. II) |
| <i>NZ</i> | <i>Numismatische Zeitschrift</i> (Vienna) |
| <i>RENLO</i> | <i>Revue de l'École Nationale des Langues Orientales</i> (Paris) |
| <i>RFLM</i> | <i>Revue de la Faculté des Lettres de Meched</i> (Mashhad) |
| <i>RFLT</i> | <i>Revue de la Faculté des Lettres et des Sciences Humaines de Téhéran</i> (Tehrān) |
| <i>RN</i> | <i>Revue numismatique</i> (Paris) |
| <i>SBWAW</i> | <i>Sitzungsberichte der Wiener (Österreichischen) Akademie der Wissenschaften</i> (Vienna) |
| <i>Syria</i> | <i>Syria</i> (revue d'art oriental et d'archéologie) (Paris) |
| <i>WZKM</i> | <i>Wiener Zeitschrift für die Kunde des Morgenlandes</i> (Vienna) |
| <i>ZDMG</i> | <i>Zeitschrift der deutschen morgenländischen Gesellschaft</i> (Wiesbaden) |

BIBLIOGRAPHY

- Haddad, F. I. and Kennedy, E. S. "Place Names of Medieval Islam". *The Geographical Review*, vol. LIV (New York, 1964), pp. 439-40.
- Ibn Yūnis, Abu'l-Ḥasan 'Alī b. 'Abd al-Raḥmān b. Aḥmad. *al-Zij al-kabīr al-Ḥākīmī* (Le Livre de la grand table Hakémite), ed. and tr. J. J. A. Caussin de Perceval in *Notices et extraits des manuscrits de la Bibliothèque Nationale etc.*, vol. VI (1) (Paris, an XXI de la république), pp. 16-240.
- Juschkeiwitsch, A. P. *Geschichte der Mathematik im Mittelalter*. Leipzig, 1964.
- Khawārazmī, Muḥammad b. Mūsā. *al-Kitāb al-mukhtaṣar fī ḥisāb al-jabr wa'l-muqābala*, ed. and tr. F. Rosen as *The Algebra of Mohammed bin Musa*. London, 1831.
- Kitāb ṣūrat al-arḍ*, ed. H. von Mžik. Leipzig, 1926.
- Levey, M. *The Algebra of Abū Kāmil... in a Commentary by Mordecai Finzi*. Madison, Wisc., 1966.
- Levey, M. and Petruck, M. *Kūshyār ibn Labbān, Principles of Hindu Reckoning*. Madison, Wisc., 1965.
- Luckey, P. "Zur Entstehung der Kugeldreiecksrechnung". *Deutsche Mathematik*, vol. V (Leipzig, 1941), pp. 405-46.
- Nallino, S. "Al-Khawārizmī e il suo rifacimento della geografia di Tolomeo". *Raccolto di scritti editi e inediti*, vol. V (Rome, 1944), pp. 458-532.
- Neugebauer, O. *The Astronomical Tables of al-Khawārizmī*. Copenhagen, 1962.
- Sayili, A. *Abdulhamid ibn Turk'un... (Logical Necessities in Mixed Equations by 'Abd al-Ḥamīd ibn Turk)*. Ankara, 1962.
- The Observatory in Islam*. Ankara, 1960.

2. Works of al-Bīrūnī

- al-Āthār al-bāqīya*, 2 vols., ed. E. Sachau. Leipzig, 1878. Tr. E. Sachau as *The Chronology of Ancient Nations*. London, 1879.
- Kitāb al-taḥfīm li awā'il ṣinā'at al-tanjīm*, tr. R. Wright as *The Book of Instruction in the Elements of the Art of Astrology*. London, 1934.
- Boilot, D. J. "L'Œuvre d'al-Beruni, essai bibliographique" in *Mélanges de l'Institut Dominica d'Études Orientales*, vol. II (Cairo, 1955), pp. 161-256.
- Kitāb fī taḥqīq mā li'l-Hind...*, ed. E. Sachau. London, 1888. Osmania Oriental Publications. Hyderabad-Deccan, 1958. Tr. E. Sachau as *Alberuni's India*, 2 vols. London, 1910.
- al-Qānūn al-Mas'ūdī*, 3 vols. Hyderabad-Deccan, 1954-6.
- Taḥdīd al-amākin*, tr. Jamil Ali as *The Determination of the Coordinates of Cities*. Beirut, 1967.

CHAPTER 12

- al-Bīrūnī. *Kitāb al-ṣaidala* (edition being prepared by 'A. Zaryāb Kho'i of the University of Tehrān).
- Browne, E. G. *Arabian Medicine*. Cambridge, 1921.
- Burckhardt, T. *Alchemy - Science of the Cosmos, Science of the Soul*, tr. W. Stoddart. London, 1967.

BIBLIOGRAPHY

- Campbell, D. E. H. *Arabian Medicine and Its Influence on the Middle Ages*, 2 vols. London, 1926.
- Corbin, H. with S. H. Nasr and O. Yahya, *Histoire de la philosophie islamique*, vol. I. Paris, 1964.
- Dīnawarī, Abū Ḥanīfa Aḥmad b. Dā'ūd. *Kitāb al-nabāt*, ed. B. Lewin (Uppsala Universitets Årsskrift, 1953: 10). Uppsala–Wiesbaden, 1953.
- Elgood, C. *A Medical History of Persia and the Eastern Caliphate*. Cambridge, 1951.
- Fonahn, A. *Zur Quellenkunde der persischen Medizin*. Leipzig, 1910.
- Holmyard, E. J. *Alchemy*. London, 1957.
- Holmyard, E. J. (tr.). *Avicennae de congelatione et conglutinatione Lapidum*. Paris, 1927.
- Ibn Qutaiba. 'Uyūn al-akḥbār, tr. L. Kopf as *The Natural History Section from a 9th Century "Book of Useful Knowledge"*. Paris–Leiden, 1959.
- Ibn Sīnā. *al-Qānūn*, tr. O. C. Gruner, as *A Treatise of the Canon of Medicine of Avicenna, Incorporating a Translation of the First Book*. London, 1930.
- ʿIsā Bak, Aḥmad. *Ta'riḫ al-bīmāristānāt fi'l-'ahd al-islāmī*. Damascus, 1939.
- Ta'riḫ al-nabāt 'ind al-'arab*. Cairo, 1944.
- Kindī, Ya'qūb b. Ishāq. *al-Aqrābādīn*, ed. and tr. M. Levey as *The Medical Formulary*. . . Madison, Wisc., 1966.
- Kraus, P. *Jābir ibn Ḥayyān*, 2 vols. Cairo, 1942–3.
- Leclerc, L. *Histoire de la médecine arabe*, 2 vols. Paris, 1876.
- Meyerhof, M. "Das Vorwort zur Drogenkunde des Bērūnī". *Quellen und Studien zur Geschichte der Naturwissenschaften und Medizin*, vol. III (iii) (1933), pp. 1–52 (151–208).
- Mieli, A. *La Science arabe et son rôle dans l'évolution scientifique mondiale*. Leiden, 1938.
- Nasr, S. H. *An Introduction to Islamic Cosmological Doctrines*. Cambridge, Mass., 1964.
- Islamic Studies*. Beirut, 1967.
- Science and Civilization in Islam*. Cambridge, Mass., 1968.
- Three Muslim Sages*. Cambridge, Mass., 1964.
- O'Leary, De Lacy D. *How Greek Science Passed to the Arabs*. London, 1949.
- Ruska, J. "Al-Razī's Buch Geheimnis der Geheimnisse". *Quellen und Studien zur Geschichte der Naturwissenschaften und Medizin*, vol. VI (1937), pp. 1–246.
- Salammoniacus, Nušādīr und Salmiak*. Heidelberg, 1923.
- Das Steinbuch des Aristoteles*. Heidelberg, 1912.
- Ṣafa, Z. *Tārīḫ-i 'ulūm-i 'aqlī dar tamaddun-i islāmī*. Tehrān, 1336/1957.
- Sarton, G. *An Introduction to the History of Science*, vol. I. Baltimore, 1927.
- Sharif, M. M. (ed.). *A History of Muslim Philosophy*, 2 vols. Wiesbaden, 1963–6.
- Siggel, A. *Das Buch der Gifte des Ġābir ibn Ḥayyān*. Wiesbaden, 1958.
- Stapleton, E. with R. F. Azo and M. Hidāyat Ḥusain. "Chemistry in 'Iraq and Persia in the Tenth Century A.D.". *MRASB*, vol. VIII (6) (1927), pp. 317–418.
- Wiedemann, E. "Aus der Botanik des muslimischen Volkes". *AGNT*, vol. III (1911), pp. 299–306.
- "Beiträge zur Mineralogie usw. bei der Araber" in *Festschrift O. Lippmann* (Berlin, 1927), pp. 48–54.